Ministry For Infrastructure Transport And Communications

Malta LRT Study

Review Study –Final Report

October 2008

Halcrow Group Limited

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1 Introduction and Objectives

1.1 Background to Report

1.1.1 The Ministry for Infrastructure Transport and Communications (MITC) in Malta has been considering a range of improvements to the transport network and operations throughout the island. The bus network is the mainstay of public transport provision and has become a national institution both for the local population and the tourist industry. It performs a vital social and economic service, and many of the routes are well patronised.

1.1.2 In 2005 Halcrow was commissioned to consider the structure of the bus industry, its regulation and the role of the Government in planning, regulating and supporting the bus network. In 2007 Halcrow was asked to undertake a strategic study into the possibility of introducing Bus Rapid Transit (BRT) along a number of corridors on the island. This follows the introduction of several BRT schemes worldwide. That study concluded that there was a significant potential to develop BRT services in the urban area, and identified a network linking Valletta with Sliema and Paceville (to the north), Malta Airport (to the south) and Cospicua (south of the Grand Harbour).

1.1.3 MITC have also considered the possibility of introducing Light Rail Transit (LRT) as a modern attractive transport system on key corridors. In July 2008 MITC launched a document which proposed reform of the public transport system. One feature of this was that a LRT/tram service would provide people with an attractive alternative to car usage. MITC indicated two separate routes – Valletta to Sliema and Valletta to Birkirkara. This report presents our initial conclusions about the prospects of introducing LRT along these corridors.

1.2 Report Objectives

1.2.1 The requirement of this study was to verify the proposed LRT network, specify it and produce a service specification and service level agreement which could be the basis for network provision by the Maltese Transport Authority (Awtorita Dwar

It-Trasport - ADT). ADT has already prepared an initial routing of the Valletta to Sliema route, and this was reviewed.

1.2.2 The key study tasks were summarised as:-

- Review of existing ADT alignment work
- Technical review of rolling stock types that may be appropriate for the Malta application, and a shortlist of types which would be the operating constraints of the island and network demand characteristics
- Review of infrastructure requirements and the interaction of options
- Assessment of alignment infrastructure engineering issues
- Assessment of alignment road user interface issues
- Initial capital cost assessment
- Maintenance and renewals cost assessment
- Initial operating cost assessment including "top down" assessment of patronage levels necessary to cover operating costs
- Broad assessment of model of procurement and funding

1.3 The Role of Light Rail Transit

1.3.1 Light Rail Transit (LRT) is a member of the family of transport modes designed to serve the requirements of the spectrum of passenger demand found in urban areas. Each mode has its own service characteristics and cost structure, and is suited to meet the requirements of a particular section of the demand spectrum. LRT is a rather imprecise term which covers a broad spectrum of technological and operational specification extending from the traditional street tramway to the suburban metro.

1.3.2 Many large cities use surface or sub-surface rapid transit as their basic transport mode and supplement it with extensive bus networks. Small cities with a much lower level of demand tend to rely on buses alone. Medium sized cities require a better service level than buses provide and yet the demand is insufficient to justify the larger scale investment requirement for a full transit system. LRT has been described as a medium-cost mode that provides a medium-speed service for a medium volume of passengers which falls into the cost/service region between conventional rail rapid transit and buses. Such medium density flows can also be found along secondary corridor routes within large conurbations.

1.3.3 LRT is capable of higher speed operation on fully segregated systems where that is possible, but also able to cope with slower semi-exclusive or mixed traffic. LRT therefore has the ability to adapt itself to the level of service required. This is reflected in the different roles which LRT systems fulfil throughout the world, ranging from upgraded street-tramway with traffic management and traffic control priorities to segregated operation with most of the route mileage on track kept separate from other transport modes

1.3.4 LRT systems can act as the basic transport model in cities, providing line-haul routes to/through the central business district (CBD), providing cross-town links or circulation within the CDB, serving specific activity centres, acting as feeders to heavy rapid transit systems, or for specific applications. The starting point for potential applications is to identify potential passenger volumes and the flexibility of LRT is such that it is possible to match the level of service provided with the forecast level of demand.

1.3.5 In terms of threshold figures to determine the extent of LRT operations, LRT becomes economically and operationally superior to buses at about 4,000 – 5,000 passenger per hour, although many LRT lines operate successfully with peak hour volumes as low as 2,000. Where peak hour flows fall below 2,000 passengers per hour in one direction bus would be the preferred means of transport. The upper threshold limit has an even wider range depending on the extent of fixed costs for a full rapid transit route. Full rapid transit systems (metros) become a more appropriate solution where volumes reach 10,000 – 20,000 passengers per hour. LRT, therefore, occupies an intermediate position within the spectrum of transport demand.

1.3.6 LRT is the modern descendent of the early 20th Century street tramway combining the higher acceleration and deceleration capabilities of the modern tram with various rapid transit features which permit higher maximum speed.

2 System Characteristics

2.1 Definition of Tramway

2.1.1 The term tramway is used to define an LRT system in which the rails are laid in a place to which the public may have access and where the permitted speed of operation is limited to that which will enable the driver to stop it within the distance he can see to be clear ahead. This is clearly the solution envisaged for the application of LRT in Malta, and we will refer hereafter to **tramway** rather than the more generic LRT.

2.1.2 Within that definition, tramways may be categorised as follows:

- **Integrated On-Street Tramways** – in which the rails are laid in the highway and the part of the highway occupied by the rails is capable of being used by other road vehicles or by pedestrians.

- **Segregated On-Street Tramways** – in which the rails are laid within the boundaries of the highway, and that part of the highway occupied by the rails may be crossed by pedestrians and other road users at designed crossing points. The tramway alignment is not normally shared with other road vehicles other than by local exception, such as service buses or emergency vehicles.

- **Off-Street Tramways** – in which the track is wholly segregated from the highway and there is no access to it by other road vehicles.

2.1.3 Clearly, the greater the extent of segregation possible, the higher the achievable average speed, as progress is not impeded by other traffic. It does however require sufficient land to be available to achieve segregation and it does make access to the tramway from the street environment more onerous.

2.2 Vehicles

2.2.1 The design of trams has evolved from small two-axle and four-axle streetcars to larger and faster cars with single, double, or now even multiple articulations, and bi-directional with ample door provision on both sides of the cars and driving cabs at both ends. The new large trams improve manpower productivity, reduce vehicle weight per passenger, and provide faster quieter, and a more comfortable ride. Low floor height vehicles to assist passenger access are now standard. Passenger carrying capacities vary according to type of vehicle from about 70 for a single car to over 250 for an 8-axle articulated vehicle. The use of articulated vehicles has allowed them to be lengthened without sacrificing their ability to negotiate tight curves. Modern trams are typically 25 to 35 metres long and 2.5 – 2.65 metres wide. Given the constraints on available space within the street environment in Malta the adoption of the narrower tram width with will be necessary.

2.2.2 Two important characteristics of trams are their ability to negotiate steep gradients and tight curves. The ability to negotiate gradients of up to 8% is a common requirement and trams capable of consistently negotiating 10% gradients are increasingly common. The ability to negotiate a curve of 18 metres radius is typical for an 8-axle articulated tram although negotiating any curve below 25 metres radius can result in unpleasant wheel squeal. The ends of modern trams are tapered not specifically to increase their visual attractiveness but to reduce the sweep of the vehicle body as it negotiates curves.

2.2.3 Modern trams are designed for high performance in terms of acceleration and deceleration, the main limitations being the comfort and safety of standing passengers. Most modern vehicles have acceleration rates of 1.2 – 1.5 metres/second^2. Braking systems combine rheostatic or regenerative braking with disc brakes to produce a retardation rate of 1.0 – 1.6 metres/second^2, with a magnetic track brake for emergency braking at 2.3 – 3.0 metres/second^2.

2.2.4 These characteristics allow tramways o following the existing terrain, saving capital costs in the route construction. However the vehicles themselves have become relatively sophisticated, adopting much of the technology advances of "heavy" rail into lighter vehicles, and they are often built to order in relatively small fleets. As a consequence the vehicles can represent up to 50% of the total capital investment required for the system.

2.3 Track

2.3.1 Track gauge is usually the international standard 1.435 metres. Track used for tramway in a rural off-street location is generally similar to conventional ballasted railway track except that lighter weight rails can be used and sleeper spacing widened because of lower axle load. For street running or in an area where pedestrians made be present or have access to, grooved rails are used, set in a concrete trackbed which is in turn embedded into the surfacing. Rails are electrically insulated to avoid leakage of the residual traction current.

2.3.2 Due to the distributed loading of the tram vehicle across its several axles and the load distributing effect of the trackbed, the imposed load of a tramway on its foundation, be it highway or otherwise, is no greater than that of a conventional heavy goods vehicle.

2.4 Tramstops, Interchanges, Termini and Park & Ride

2.4.1 Stopping places for a tramway can range from a simple sign on a pole to an elaborate underground station with escalator access. They are usually equipped with a passenger shelter, a ticket machine, a real-time passenger information system and are under CCTV surveillance from the OCC. The fundamental characteristic is their low level, typically only 380mm above rail level allowing fully-accessible level boarding of the tram.

2.4.2 The type and design of a tramstop is determined chiefly by the degree to which the route is segregated from other traffic. Tramstops on segregated sections are usually island platforms situated between the tracks to minimise land-take and feature marked crossing points of the tracks for passenger access. Tramstops in-street are usually side platforms integrated with the adjacent footway and are usually achieved by its localised footway ramping-up. Traffic signal crossing protection is frequently provided for busy tramstops to give pedestrians a safe road crossing route. Spacing of tramstops is greater than that of a bus network, and their sites are usually selected to ensure maximum passenger attraction.

2.4.3 Interchanges with the bus network tend to be more elaborate and are necessarily designed and located carefully to encourage and enable efficient modal interchange. Termini are preferably located off-street to allow trams to turn back by changing track from outbound to inbound direction without obstructing traffic, the driver then changing his driving position to the other end of the vehicle.

2.4.4 Park & Ride is generally accepted as an essential feature of modern tramway systems. If car drivers are to be encouraged to routinely switch mode to tram for their daily journeys, that has to be enabled by providing sufficient and secure car parking facilities at selected tramstops or at the termini at locations conveniently accessible from the road network. Care must be taken however to ensure that car parking provision in the vicinity of other tramstops is carefully managed to ensure that all-day parking by tramway passengers is not to the detriment the facilities needed by local residents and traders.

2.5 Power Supply

2.5.1 Tramways systems are typically powered by a 750 volt direct current (DC) supply supplied from overhead lines mounted on traction poles located at frequent intervals along the route or supported by insulated fixings to adjacent buildings. The DC current is supplied from traction substations located at occasional intervals along the route and particularly close to termini. These in turn are fed by high voltage AC supplies from the strategic electricity supply network.

2.5.2 The overhead line system need not be intrinsically ugly as modern materials and efficient design can reduce the visual clutter. The traction power is collected by the trams by pantograph mounted on the roof and the very low residual return current from the traction motors is routed through the tram wheels and back along the insulated rails to the traction substations. This power supply system is intrinsically safe and proven in use for decades.

2.5.3 Alternative power supply arrangements such as underground conduits are currently being trialled but are far from being considered proven and reliable in use. The alternative of diesel traction is outlined in a later section.

2.6 Signalling

2.6.1 The need for a signalling system is a compromise between economy and the safety/speed of operations. Modern tramways are largely un-signalled with the driver ensuring passenger safety in the same way as any other road user. Signals are required at busy intersections to ensure tram priority over other road users and are integrated with the road signal phase sequencing. Road traffic signal installations can also be introduced to provide trams with priority access to sections of route shared with other traffic to avoid their being obstructed by traffic ahead.

2.7 Depot & Control Centre

2.7.1 In order to achieve the required high degree of reliability in service, it is essential that both the infrastructure and the vehicles are maintained to a proper standard. A depot is therefore required within which routine cleaning and safety checks can be carried out on the vehicles whilst they are securely stabled (in the open) overnight, and essential light and heavy maintenance work undertaken under cover in a fully-equipped depot building.

2.7.2 That depot building can double as the Operational Control Centre (OCC) for the system, wherein system controllers monitor in real time the integrity and safety of the power supply, and through CCTV and vehicle location data, the performance and timekeeping of the fleet; and are able to intervene to manage incidents that might arise such as obstructive parking, traffic congestion or traffic signal failure.

2.7.3 A depot requires a significant area of land for stabling and vehicle preparation, and tends to be an unpopular neighbour as it operates throughout the night under floodlights. A location outwith the built-up area would therefore be the most favourable.

2.8 Fare System

2.8.1 A tram driver, for reasons of security and safety, is separated from the passengers within a separate cab in the vehicle. As a consequence the driver is not available to issue tickets and a self-service off-vehicle ticket purchasing system is usually adopted, with passengers buying tickets in advance of travel, either from ticket machines at tramstops or from local shops. Such self service fare collection has become standard for tramway systems and permits fast loading of passengers, but does need effective policing to minimise the extent of fare evasion. Additional on-vehicle sales can be achieved by deploying on-board conductors or the use of on-board ticket machines. Some systems routinely deploy conductors for both passenger assistance and advice purposes and for revenue control.

2.8.2 There are considerable savings in using an “off vehicle” fares system, but this would need to be adopted also by the bus network in order to provide an integrated ticketing service.

3 Existing ADT Proposals and Alignment

3.1 Introduction

3.1.1 As stated by the Minister of Transport and reflected within the terms of reference, the study considered the feasibility of introducing tram links from Valletta to Sliema and from Valletta to Birkirkara.

3.2 Valletta to Sliema Route

3.2.1 Most development work so far has gone into this route. ADT have investigated this route in some detail and have prepared a route alignment design. It involves:-

- About 5.5 km of twin track route running along the harbour front from Valletta to Sliema
- A tram terminus in Valletta on the vacant site below to the Phoenicia Hotel adjacent to (but immediately below) the existing bus terminus
- Seven or eight intermediate tramstops
- A tram terminus at Sliema along the seafront to the west of the central area

3.2.2 We have reviewed these proposals in Section 4.

3.3 Valetta to Birkirkara Route

3.3.1 Very little development work had been undertaken to date on the alignment to be adopted for this route, and attention had focussed of the route of the abandoned Malta Railway.

3.3.2 The former railway route was investigated as part of this study to see if it would be suitable to be used for a tram route between Valletta and Birkirkara. The Malta Railway from Valletta to Rabat operated between 1883 and 1931. It was a single track metre gauge route, with passing paces as the stations. There were 10 stations at Valletta, Floriana, Hamrun, Msida, San Antonio, Birkirkara, Attard, San Salvatore, Notabile, and Museum. Journey time was 30 – 35 minutes end to end. Whilst initially financially successful, the railway was affected after the First World War by both increasing competition from buses and by a significant increase in costs. These affects led to repeated annual loses, and the railway was closed in 1931 and the route abandoned.

3.3.3 This route has also been considered before as a possible right of way for other transport modes, most recently the 0.8 km tunnel section underneath Floriana to Valletta was considered by the Halcrow BRT study. The comments on this proposal are :-

- Whilst the former Valletta railway station was large (13.1 metres wide by 9.9 metres high arch) and would appear to be reusable, it immediately feeds into the 835 metre Floriana tunnel.
- The Floriana tunnel was only single track and its arch measured 4.6 metres wide by 4.3 metres high. Because of an underground lake discovered during construction the tunnel had to be built with a gentle S-shaped curve. Since the railway's closure the tunnel has been used as a right of way by several utilities. Significant cabling and empty cable drums can be seen at the Valletta end. It is doubtful therefore if the tunnel could be reused without significant renovation. Even then it would pose a significant operational bottleneck as it could only ever accommodate a single track
- Whilst the former railway station at Hamrun still exists (used by the Scouts as their headquarters for many years) parts of the alignment through Hamrun have been developed on, in particularly by a large church. An alternative alignment would need to be sought.
- Most of the rest of the former route has now been converted into a road (Triq Il-Ferrovija) through Santa Venera, crossing the North/South Route One trunk road at a roundabout. It should be possible to reuse this route using a "street tramway" system mixed with other traffic if required.
- The former railway station at Birkirkara has been well preserved and surrounded by a well designed small park. The current Birkirkara bus terminus is just to the east of this park. The tram route could also terminate here but its location is on the edge of the town centre.

3.3.4 It is our conclusion that the old railway route would not be a practical proposition for tramway implementation. Our study then turned to examining alternative alignments. (See next Section)

4 Possible Route Alignments

4.1 Introduction

4.1.1 The original concept was for two separate tram routes - the route to Sliema following the coast, and the route to Birkirkara following the former Malta Railway alignment. This study has however sought to integrate the proposals for the two tram routes together into a cohesive network, which has many significant advantages.

4.1.2 Some alternative route alignment options were also investigated, principally for the route to Birkirkara. A description and map showing the two preferred route alignments can be found in Appendix A.

4.2 Valletta to Sliema

4.2.1 This route alignment design as developed by ADT is illustrated in plan in Appendix B and photographically in Appendix C. Our comments on the proposed route are:-

- The site for the tram terminus in Valletta is large and would be suitable, and could conceivably used to accommodate a tram depot or stabling sidings, provided the two existing redundant buildings on the site were removed.
- It would be necessary to construct escalator/lift access from the proposed tram terminus to the level of bus station in order to provide a proper interchange there. The current single pedestrian stairway would be inadequate.
- The entrance/exit from the terminus is currently constricted by the Bastion Walls and a footbridge which is part of the garden walk of the Phoenicia hotel. It would be necessary to either enlarge this access or to tunnel beneath it.
- If crossed at grade, it would be necessary to provide a signalled crossing of the busy Triq L-Assedju L-Kbir road, especially as the tram route proceeds down Hannibal Scicluna with about a gradient up to 10% to the Msida Bastion. It would be important to avoid trams stopping on this steeply graded section
- At present the route alignment at the bottom of the hill conflicts with the naval berths, but it is understood that there is a proposal for the location of the naval berths to be moved and that the seafront would then be redeveloped to form an attractive leisure destination.

- The Gozo ferry berth, with its significant heavy lorry traffic, also conflicts with the tram route. Whilst this berth will be developed to its increase capacity, many lorries wait at this location for the ferry and could block the route. Alternative vehicle marshalling facilities off the tram route would be necessary.
- We consider the proposed construction of two short bridges at Pieta and Msida to avoid the storm drain outfalls worthy of reconsideration, as sufficient land could be available at these locations to make them unnecessary.
- There has been considerable discussion about the sharp bend along Triq Marina and the constrained width there. The width is insufficient to allow a two lane road in each direction and separate twin tram tracks. We consider the suggestion of making a three lane road including a reversible "peak hour direction" middle lane as too dangerous a solution for this bend. A short (1 km) single track section to the tram route could be possible, but given the intended service level, would be a significant constraint to reliable service frequencies. It is our considered view that the trams could operated in shared traffic mode with other traffic along the road at this location, provided advance traffic priority was given to trams ready to emerge from the tramstops at each end of this section thereby having the effect of providing an uncongested way forward.
- The bus stops at Msida are an important interchange location, with many passengers transferring between bus services. The tram route should build upon this interchange by allowing easy transfer between tram and bus
- Whilst the tram route follows the coastal route around Ta'Xbiex the northbound bus routes and general traffic uses Triq D'Argenes/Triq L'Imsida and southbound bus routes and general traffic uses Triq L'Abate Rigord, both of which are more direct but congested routes to Sliema. We propose that the outbound tram route run in shared traffic mode in the upper coastal road, which would also be outbound only; with the inbound tram route run in shared traffic mode in the lower coastal road, which would also be inbound only.
- At Manoel bridge the existing petrol station and kiosk will have to be relocated and a new bridge onto the island provided. Whilst Manoel Island, as a former yacht repair facility, could provide a suitable site for the tram depot its impending redevelopment as an exclusive leisure and residential location makes that much less acceptable.
- Locating the route along the esplanade to Sliema should be relatively straightforward. With both northbound and southbound routes on the "sea" side and most buildings and activities on the "land" side it will be necessary to

enhance the pedestrian crossing facilities to allow passenger safe access/egress across the road to/from the tramstops.

- The proposed tram terminus is Sliema is located to the west of the existing bus bay along the esplanade. This is considered too far from the centre of town and it would be preferable to locate it further east. With the construction of the new developments at Tigne there will be an eastwards shift in the town's polarity. With the need to provide for bus/tram interchange in Sliema it is proposed that part of the existing central car park site be redeveloped as a tram/bus interchange and an underground car park be constructed to accommodate the cars displaced. If some of the bus routes through Sliema are scaled back in preference for feeder buses into the tram system, significant numbers of people will need to interchange at this location.

4.2.2 **Summary Route (Red Line)**

- Sliema Central Terminus

- Triq Marina
- Triq Ix-Xatt
- Ta' Xbiex Yacht Berths
- Ix-Xatt Ta'Xbiex
- Msida Creek Drain
- Msida Creek Gardens
- Ix-Xatt Ta'L-Ismida
- Triq Marina
- Xatt It-Tiben
- Hay Wharf
- Navy Yard Development (common with Blue Line)
- Hannibal Scicluna (common with Blue Line)
- Valletta Central Terminus (common with Blue Line)

4.2.3 **Proposed Tramstops**

- Sliema Ferry
- Manoel Island Bridge
- Ta' Xbiex Gardens
- Mare Nostrum

- Ta' Xbiex Marina
- Msida Creek (bus interchange)
- Sa Maison (Interchange with Blue Line)
- Navy Yard Development (common with Blue Line)
- Valletta Interchange(common with Blue Line)

4.2.4 We considered a variation to the route proposed by ADT at the Valletta end to divert it through the Jubilee Grove up Triq Il-Principessa Melita and along Triq Sant' Anna through the heart of Floriana, terminating in Triq Nelson on the western edge of the bus station in Valletta. This could have offered several advantages:-

- It provides a link with the bus interchange location near Porte des Bombes
- The Triq Il-Principessa Melita route is wide with two lanes of traffic in each direction, two wide pavements, and a side road. It should be possible to develop a tram right-of-way up this hill
- It provides a much better connection to the heart of the important business centre of Floriana
- It avoids difficulties with the Gozo ferry and with the navy berths
- The route up Triq Il-Principessa Melita is not as steep as Hannibal Scicluna
- The obstacle of the Bastion Walls with the consequent need for engineering works to overcome them, would be avoided
- The tram terminus at Triq Nelson would be level with and so provide easier access to the existing Valletta bus station.

4.2.5 We were advised by MITC colleagues that the impending redevelopment of the naval berths at Sa Maison to provide an attractive leisure destination made routing the tramway to Valletta via that location, in accordance with the ADT proposal, the preferable option. Following the subsequent presentation of our draft report to the Minister however, MITC has re-thought the matter. It is now likely that a large part of our alternative route proposal outlined in Section 4.2.4 above will be adopted, subject to detailed engineering assessment of the precise routing in Floriana and at Valletta terminus

4.3 *Valletta to Birkirkara*

4.3.1 Given the impracticality of the Malta Railway route, several potential rights of way have been identified to try and link Birkirkara into the tram network. We consider it essential that the route to Birkirkara be linked into the route to Sliema to develop a "network" rather than two independent routes. It would provide a valuable interchange for the routes without the need to travel all the way to Valletta terminus, and permit interoperability of vehicle fleets, and the use of a common depot and operational facilities. Implementing two independent routes would be significantly more expensive.

4.3.2 An important constraint in developing the route to Birkirkara is how to cross the north/south Route One (Triq Regjonali) trunk road. This is commented in the possible route alternatives considered:-

- North west from the Msida interchange up the hill to the roundabout with Route One at Tal-Hriereb, west alongside Triq Dun Karm connecting with the Meter Dei hospital and the University of Malta campus and then accessing through the north of Birkirkara into the centre of the town. Triq Dun Karm is a major route with a significant grade separated junction with the hospital/university. The roundabout at Tal-Hriereb also presents challenges due to the gradients and its design
- Due west from the Msida interchange along Triq Il-Wied Ta' L-Imsida, through the commercial area, and accessing the Birkirkara bus terminus through the side streets. This has significant advantages in being the most direct and shortest, has a wide right of way which should accommodate a dedicated tram-route, and passes underneath a grade separated junction with Route One. To access Birkirkara bus station, it is likely that the eastbound and westbound tracks will need to be separated along different side streets due to their restricted width, but this will only be for a very short distance. The main concern using this route is that it is at the bottom of a valley and it is affected by flash foods during torrential rain. The storm drain can be seen at the Birkirkara end which discharges into Msida creek (see Appendix C).
- South east from Msida interchange, past the Polytechnic (College of Arts Science, and Technology) to Santa Venera to join with the route of the former railway line (Triq Il-Ferrovija), to the Birkirkara bus interchange. This crosses Route One at a simple roundabout near St Philips Hospital. The link to the Msida interchange could pose some challenges due to the narrowness of the streets at the Msida end.
- The route of the former old tram route from Valletta to Birkirkara, via the centre of Floriana, Triq San Guzepp, Triq Il Kbira, and Triq Fleur de Lys. This has the advantages of linking several economic centres together (Valletta, Floriana, Hamrun, Santa Venera, Fleur de Lys and Birkirkara, suggesting significantly more intermediate traffic. A variation to this would be to take the tram route down an alternative Jubilee Grove route in order to connect with

the Sliema route and to access the tram terminus in Valletta.

4.3.3 These options were discussed with MITC colleagues and the latter route option was selected for further examination with the request to extend it out to the National Stadium at Ta'Qali rather than at Birkirkara.

4.4 Valletta-Birkirkara-Ta'Qali National Stadium

4.4.1 The advantages of this extended 8.5 km route are:-

- It will link several significant nodal centres together which could generate additional intermediate patronage (Hamrun, Santa Venera, Fleur de Lys, Birkirkara, Attard, Misrah Kola, Pitkali Market, as well as Valletta and the National Stadium).

- By providing a high quality public transport route through these centres it should have a positive regenerative economic impact upon them

- It will run through Hamrun and Birkirkara on the route previously used as the old tramway. From there through Attard it would use part of the former route alignment of the old Malta Railway

- It will provide a direct link with the National Stadium and be a significant means of transport to get people to the stadium during major events there

- It will link in with the existing extensive car parking facilities around the National Stadium and provide a valuable Park & Ride side for passengers travelling to Attard, Birkirkara, Hamrun and Valletta. This will help reduce traffic congestion in these urban centres

- It will link with the Valletta-Sliema tram route near the Gozo ferry terminal to provide an integrated tram network and allow through routing of trams from Sliema and Msida to Birkirkara and Ta'Qali

- Tram stops will be located at approximately every 500 metres through the urban centres of Hamrun and Fleur de Lys and approximately every 625 metres from there to the National Stadium. An intermediate terminus facility will provided at Birkirkara town centre which will allow many of the off-peak trams to turnback there rather than running lightly loaded through to Ta'Qali

- The extent of the lands surrounding the National Stadium at Ta'Qali will provide enough land to develop an out-of-town depot to service the trams for both routes.

4.4.2 As this route is almost entirely street running there will inevitably be issues surrounding the maintenance of on-street parking and loading facilities and of continued access by motor vehicle along the route. In sections where the alignment cannot accommodate both parking and two traffic/tramway shared lanes (see typical crossections appended) it is our experience that it is likely to be more acceptable to residents and businesses to provide parking/loading facilities at the expense of traffic capacity, restricting traffic to one direction access only for example. Going forward, a detailed "frontager" survey along the whole route will be required in order to determine the precise needs of the communities affected and to develop location-specific solutions to overcome particular alignment pinch-points.

4.4.3 **Summary Route (Blue Line)**

- Ta'Qali National Stadium Car Park
- Triq Il-Pitkali (passing St Catherine's Old Peoples Residence)
- Triq Il-Linja
- Triq Birkirkara (passing St Anton Gardens)
- Triq Birbal
- Triq Il-Wied (passing St Teresa's Church)
- Triq Il-Wied (Birkirkara Main Street)
- Triq Fleur De Lys (passing Station Gardens and present bus terminus)
- Triq Fleur-De-Lys
- Fleur-De-Lys Roundabout (replace with signalled junction)
- Triq Il Kbira San Guzepp (passing Government Offices)
- Triq San Guzepp (passing Hamrun Church)
- Monument Ta'Spencer Obelisk
- Triq Dun Georg Preca (passing St Josephs School & Ta'Braxia Cemetery)
- Triq Joe Gasin
- Crossing of Triq L-Independenza
- Triq W Bonnici (passing the Bocci Club)
- Ix Xatt It-Tiben (common with Red Line)
- Hay Wharf (common with Red Line)

- Navy Yard Development (common with Red Line)
- Hannibal Scicluna (common with Red Line)
- Valletta Terminus (common with Red Line)

4.4.4 **Proposed Tramstops**

- National Stadium
- Ta'Qali National Park
- Pitkali Market
- Il-Pitkali
- Il-Linja
- San Anton Gardens
- Birbal
- Birkirkara Centre (intermediate terminus/turnback)
- Fleur-de-Lys
- Umberto Colosso
- Casa Leone
- Il-Kbira San Guzepp
- Hamrun Church
- Hamrun Centre
- Monument Ta' Spencer
- Sa Maison (interchange with Red Line)
- Navy Yard Development (common with Red Line)
- Valletta Terminus

4.4.5 Again, following the subsequent presentation of our draft report to the Minister, MITC has re-thought the matter of accessing Valletta terminus via the naval berths at Sa Maison. This then brings into question the desirability of routing Valletta bound trams from Birkirkara down Triq Dun Gorg Preca to an interchange with the Sliema route at Sa Maison and then back up Triq Il-Principessa Melita towards Valletta. This would be a significant route deviation and impose an unnecessary additional journey time.

4.4.6 It is our view that the appropriate location for the Birkirkara/Sliema route interchange in this new routing scenario would be at in the vicinity of the established bus route interchange at the Porte de Bombes. Thus the Valletta-bound route from Birkirkara would extend from the Monument Ta' Spencer along or immediately alongside the Triq Nazzjonali to that point, with Birkirkara trams then sharing and whatever routing through Floriana is finally selected for the Sliema trams to the Valletta terminus.

5 Rolling Stock and Operational Review

5.1 Vehicle Options

5.1.1 There is a wide variety of vehicles available in the light rail market. These range from traditional street trams to what amount to lightweight trains.

- **Lightweight railcar -** These are larger vehicles more aimed at providing low cost railcars for main line railways. They often incorporate features commonly associated with light rail, such as vehicle articulation, and partial low floor configuration and could be appropriate for post-metro operations. Unlike almost all light rail vehicles, they are widely operated under diesel rather than electric power. Examples include the low floor Bombardier Talent, Alstom Coradia Lint and Siemens Desiro
- **Light metro** - This uses light rail vehicles, including tram type vehicles to provide a low cost segregated metro operation. An example of this is the UK's Tyne and Wear system which uses tram based vehicles in a metro operational environment on former heavy rail route.
- **Pre-metro** - This term generally describes a tramway with some metro features such as segregated fast sections and underground sections, often with a view to metro conversion. An example of this can be found in the Brussels tram system where underground stations are shared with the heavy metro system.
- **Tram-train** - This term describes a service operated by tram-type vehicles, but which additionally runs on heavy rail routes during the journey in semi-metro fashion. Several examples of such operations are to be found in Germany and enable the urban tram and suburban railway to be integrated.
- **Street Tram** - This is an urban transport vehicle generally intended to run on or alongside existing streets. These will run on street (street metro), on dedicated reservations adjacent to the carriageway or on off-street sections, interfacing with the street where necessary (semi-metro). New trams in Europe and North America are required to provide low floor access for the mobility impaired.

5.1.2 This study will concentrate on identifying vehicles suitable for operating in a predominantly street-running environment. An appendix shows all the vehicle types for which technical and cost data was sought. Owing to gaps in the data for different types and the variability in specifications, it is difficult to compare the data clearly. However, it is worth summarising the different attributes of different types here.

5.1.3 Lightweight railcars are represented in the European market by products such as the Alstom Coradia Lint, Bombardier Talent and Siemens Desiro. All three offer low floor capability but are essentially lightweight diesel multiple units and are used on heavy rail branch operations. One vehicle that has more tram features is the Stadler Be4/6 and Be 6/8 used in lightweight rail applications in Switzerland. Capital costs of the vehicles themselves are comparable with those of a tram, but they would require substantial infrastructure to be constructed and fuelling facilities to be available. These vehicles are also built to main line railway dimensions rather than street tram (a Talent is 2.95m wide, as opposed to a typical street tram width of 2.4-2.65m) and are therefore likely to be unsuitable for street operation.

5.1.4 Light metro vehicles are rarer. Probably the best current example is the Manchester Metrolink vehicle. While this system incorporates street running and drive-on-sight operation, the vehicles are high floor. Bombardier is providing additional vehicles at present to Manchester based on its Flexity platform. Cost is €2.125m per vehicle reflecting simpler high floor technology. Such a vehicle would probably be unsuitable for Malta as it would necessitate the construction of full height on street platforms.

5.1.5 Pre-metro, tram-train and street tram vehicles are all derived from the same type of vehicle. Now predominantly low floor in configuration, they are available in variable length and width configurations. Typical gradient capability is 6-7% where known. This is not sufficient for Malta's needs, where a 10% maximum gradient needs to be operated. However, most trams have only half their axles or wheel pairs motored. An older example of a Siemens tram provided in 1992 to Sheffield (UK) meets a specification for 10% maximum gradient, plus the capability to push a failed tram, by motoring all axles. This can be achieved with current technology in a 100% low floor tram. However, costs have only been found for more conventionally motored trams and may be slightly higher for a fully motored Malta variant. The typical cost of a modern low floor tram appears to be around €2.7m, though this can vary considerably depending on specification and the timing of the order with scheduled production runs at the manufacturer.

5.1.6 Diesel powered trams are rare. Trams are generally design with electric power in mind. Those diesel variants which do exist are generally standard electric drive trams fitted with additional diesel generators and fuel tanks. This increases overall weight and axle loadings, and thus the likely infrastructure construction and maintenance cost. Additional weight also has a performance penalty. Diesel powered trams produce more noise and air pollution. Maintenance costs are also higher as diesel powered vehicles have more moving parts and higher vibration levels are likely to shorten the life of a number of components.

5.1.7 Halcrow has had experience of testing the feasibility on paper of diesel powered tram-derived vehicles in consultation with a major manufacturer. The capital cost of a diesel variant from this experience may be some 25% higher than for a standard electric vehicle. This is partly because of the need to add equipment to the existing vehicle, but also because of the relatively small production runs involved compared to the more standard electric variants. Diesel trams in front line intensive daily operation are a largely unproven idea, and this novelty is likely to be a problem in terms of the cost of maintenance and contingency back-up. Also, depreciation or leasing costs may be higher as their resale value would be low compared to more standard light rail vehicles.

5.1.8 A diesel variant of the Siemens Combino low floor tram does exist, and is fitted with a diesel motor for movements along a section beyond the electrified system. Owing to its low floor interior space is sacrificed in order to accommodate the engine and fuel tank, thus reducing capacity. .

5.1.9 One further vehicle is the Parry People Mover. This is an LPG hybrid powered vehicle produced by an independent UK manufacturer. It is in principle available in a number of configurations including low floor tram-style variants. However, no such versions have yet been manufactured and the vehicle has had very limited application in its home market, principally as a shuttle vehicle in specialised sites and as a tourist attraction. Lack of production volume means that costs and back-up provision would be difficult to predict and may be relatively costly. With regards to potential application in Malta it should be regarded as unproven.

5.2 Operational Parameters

5.2.1 The estimates in this document are based on the construction of two lines in Malta. The first, (designated Red) runs for just under 5.5km from Valletta to Sliema via Sa Maison. The second, (designated Blue) runs from a junction with the

Red route at Sa Maison to the National Stadium (a distance of 8.5km) via Birkirkara (4.25km from Sa Maison).

5.2.2 The services over these lines are assumed to run as follows below. For the purposes of developing costings and requirements in this document, the service is assumed to run daily from 0600 to 2400, except for Christmas Day. Peak hours are assumed to be 0700 to 0900 and 1630 to 1830.

5.2.3 The Red Line service will run the entire length the Red route. The frequency will be one tram in each direction every 10 minutes. In addition to this frequency will be increased to every 5 minutes during the peak hours. This will be referred to in terms of trams per hour (tph), giving 6tph and 12tph respectively.

5.2.4 The Blue Line service starts on the Red route at Valletta, diverging at Sa Maison and running via Birkirkara to the National Stadium. The service frequency is 10 minutes (6tph).

5.2.5 Journey times are estimated on the assumption of an average speed of 23km/h, and some running at 28km/h on the outer sections of the Blue route. This gives journey times as follows:

- Valletta – Sliema, 15 mins.
- Valletta – National Stadium, 21 mins.

5.2.6 In addition to this a minimum turnaround time of 5 minutes is used. In the case of the National Stadium services frequencies mean that the turnaround is actually 9 minutes. This is due to the frequency in combination with journey time. A more detailed simulation would be needed to see if a more productive solution could be found.

5.2.7 The combination of frequency and running time requirements generates a need for around 14 trams to operate the service. This does not include any built in spare provision. We are assuming two further vehicles, one as an operational spare, and one as maintenance spare. The four vehicles that allow for higher peak frequencies on the Red Line service will also spend parts of the operational day nominally spare, and would also in practice allow vehicles to be rotated for maintenance. The precise need for operational and maintenance spare trams would have to be determined by a detailed assessment and simulation of the service and maintenance cycle.

5.2.8 The busiest section of the system is the Red route section between Valletta and Sa Maison. This sees 12 tph off peak and 18 tph during the peak hours, and average frequency of 5 min. and 3 min. 20 sec. In practice the frequency will be slightly irregular in order to allow Blue Line services to be pathed through Red Line peak services. Frequencies would in practice vary between 2.5 and 5 minutes in the peak and 2.5 and 7.5 minutes off peak. These are tight margins and would need to be fully simulated to be considered properly proven.

5.3 *Costing Assumptions*

5.3.1 The number of daily journeys, kilometres run and hours operated are shown in Table 5.1 below. These have been used to calculate any costs driven by distance or time.

Table 5.1: Rolling Stock Utilisation

Sets	Daily Kilometres	Daily Trips	Trip duration (hrs)	Running hours	Trip duration to Depot (hrs)	Total Hours
Red Set 1	302.50	55	0.33	18.15	0.40	18.55
Red Set 2	302.50	55	0.33	18.15	0.40	18.55
Red Set 3	297.00	54	0.33	17.82	0.40	18.22
Red Set 4	297.00	54	0.33	17.82	0.40	18.22
Red Set 5 (peak)	66.00	12	0.33	3.96	0.81	4.77
Red Set 6 (peak)	66.00	12	0.33	3.96	0.81	4.77
Red Set 7 (peak)	60.50	11	0.33	3.63	0.81	4.44
Red Set 8 (peak)	60.50	11	0.33	3.63	0.81	4.44
Blue Set 9 Stadium	370.50	38	0.33	12.54	0.40	12.94
Blue Set 10 Stadium	370.50	38	0.33	12.54	0.15	12.69
Blue Set 11 Stadium	351.00	36	0.67	24.12	0.40	24.52
Blue Set 12 Stadium	351.00	36	0.67	24.12	0.00	24.12
Blue Set 13 Stadium	351.00	36	0.67	24.12	0.40	24.52
Blue Set 14 Stadium	351.00	36	0.67	24.12	0.00	24.12
Spare 1						
Spare 2						
Total	**3597.00**	**484**		**208.68**		**214.87**

5.3.2 Electrical power costs have been estimated using the Enemalta tariff for industrial users consuming more than 5m kW per year. This gives a cost of €0.0606 per kWh. This figure is multiplied by the number of trams, their estimated energy consumption and the number of hours operated.

5.3.3 The energy consumption of a tram is derived from that of the Siemens vehicles for Sheffield. These are rated at 1mW to meet the high Sheffield specification. It is our opinion that this is slightly over-specified for the gradient required, and so we have assumed a Malta tram will be rated at 750kW. From our experience we understand that on average approximately 35% of that maximum rating will be used, in this case 262.5kW. For a diesel variant we have assumed a fuel consumption of 291.3 litres/100 km. All of these figures would need to be verified in a detailed feasibility exercise.

5.3.4 Vehicle maintenance costs are based on experience in other light rail diesel situation, giving €0.56/km for a diesel and €0.45/km for electric (approximately

20% less). This is assumed to include all staff and equipment costs, but not depot capital costs.

5.3.5 Staff assumed to be required comprises 42 drivers and 5 cleaning staff. For diesel trams the cleaning complement is doubled to cover fuelling duties. 42 drivers are derived from the number of eight hour instances required to run the service 364 days per year. A lesser service will require fewer drivers. A complement of five inspectors and five control staff is also assumed. Five staff allows for 3 shift cover plus rest day and general purpose relief cover. Staff is assumed to work an average 40 hour week. Pay rates are based on a bus driver's rate for a 48 hour week, but paid instead for 40 hours, giving a 20% uplift to an hourly rate of €3.56. Employer overheads for these staff are costed at €2,000 per head per year.

5.4 Estimated Costs

5.4.1 From the above factors we have estimated the daily operating cost to be €7,246 for electric trams and €7,288 for diesel trams. This equals €2.01 and €2.03 per km respectively, or €33.72 and €33.92 per hour operated.

5.4.2 To this will need to be added the cost of acquiring the vehicles. Using a benchmark price of €2.7m per vehicle, or 25% higher (€3.375M) for diesel power. We have assumed the vehicles are lease financed at 7.5% interest over 25 years, the daily cost of the vehicles will be around €9.2k and €11.5k respectively for electric and diesel power. Outright purchase is assumed to cost the same overall as it will have to take account of asset depreciation. A detailed assessment of likely financing rates and depreciation should be carried out before making final decisions on finance, especially in the case of a diesel option, which is likely to be subject to greater financial uncertainty.

5.4.3 Costs relating to diesel powered trams do not include additional infrastructure costs for the provision of fuel tanks (either underground or in bunded areas) or the additional impact of fuel deliveries by road. Give the fuel consumption cited above, the fleet would empty a 15,000 litre tank every week. The capacity of a fuel truck is around 35,000 litres. There would need to be a guaranteed delivery every fortnight or the system would stop running. In practice, to ensure that there is always sufficient fuel, this would have to be more frequent, generating additional road journeys. The cost of a fixed tank is relatively low (around €5.6k) but there would need to be additional works to install and secure it. Fuel storage would also create additional safety and security concerns.

5.5 Conclusions

5.5.1 The most appropriate vehicle for application in Malta is most likely to be a mainstream low floor electric tram from a major manufacturer. Such a vehicle would have the advantage of using proven technology with significant spares and maintenance back-up if needed.

5.5.2 Electric vehicles would be cheaper to acquire and operate overall and have lower depreciation that the diesel-powered alternative.

5.5.3 The current modular design of trams also means that lengthening vehicles by incremental amounts to meet longer term increases in demand should also be feasible if needed. Models such as the Siemens ULF, AnsaldoBreda Sirio and the Eurotram-derived variants of Bombardier's Flexity family would be appropriate vehicles.

6 System Costs

6.1 Capital and Operating & Maintenance Costs

6.1.1 Halcrow has undertaken several major LRT assignments and is familiar with the operations of various transit systems worldwide. As part of its involvement with the Caen GLT (Guided Light Transit) system in France, Halcrow reviewed the construction, maintenance, and operating costs of a number of transit systems worldwide to produce benchmarks against which the costs of the Caen system could be compared. The three principal sources of such cost information were:-

- The national transit database from the Federal Transit Administration of America, from which it was possible to format the detailed operating costs for 25 LRT systems, as well as statistics on their level of patronage and extent of fleet operations
- A summary of comparative LRT cost and performance data produced by Egis Semaly & Faber Maunsell of eight French and five British systems
- A detailed report on the role of LRT to improve public transport in Britain produced by the Government's National Audit Office which reviewed the costs of seven transit systems in the UK.

6.1.2 The benchmark data obtained from the Caen study was updated to current (2008) levels and used to provide basic unit costs for the system proposed for Malta. It is recognised that the LRT costs relate to European or American systems and that the cost rates on Malta are likely to be somewhat lower. Offsetting this, however, is that there is no tram/rail manufacturing capability on the island and that all the equipment will have to be imported, and much of it will need to be installed by European engineers. The unit cost data for investment (capital) cost and for operating & maintenance costs (O&M) is summarised in Table 6.1 & 6.2 below, and applied to the principal operating parameters of the proposed tram system in Malta (14 route kms and 1.14 million vehicle kms).

Table 6.1: Capital Cost Estimate

	Average French Systems			Average British Systems		
Alternative Cost Category	**Unit Cost (€)**		**Malta Cost (€Mill)**	**Unit Cost (€)**		**Malta Cost (€Mill)**
Capital Cost (Per Route Length)	**23.2**	€Mill per route km	**325**	**14.7**	€Mill per route km	**206**
Capital Cost (Per Tram Usage)	**179.5**	€Mill per mill veh. kms	**205**	**128.0**	€Mill per mill veh. kms	**146**
Average Cost (€ Million)			**265**			**176**

Table 6.2: Operating & Maintenance Cost Estimate

	Average American (LTA) Systems			Average European Systems		
Cost Category	**Unit Cost (€)**		**Malta Cost (€000)**	**Unit Cost (€)**		**Malta Cost (€000)**
O&M Cost	**6.32**	per 000 veh kms	**7,207**	**6.65**	per 000 veh kms	**7,582**
Vehicle Maintenance Cost	**1.49**	per 000 veh kms	**1,702**	**1.53**	per 000 veh kms	**1,744**
Infrastructure Maintenance Cost	**130**	€000 per route km	**1,816**	**98**	€000 per route km	**1,367**
Total Maintenance Cost (€000)			**3,518**			**3,111**

6.1.3 Table 6.1 produces a range of capital cost estimates depending on the criteria chosen (€146 - €325 million). Taking an overall average leads to a capital cost estimate of €221 million. British systems are cheaper than French systems as they often use existing/former rail route alignments whereas there are more street running tramways in France. In addition there are differences in the approach to how the capital cost of diverting services and utilities is attributed.

6.1.4 The O&M cost estimate in Table 6.2 was derived from various American and European systems and lead to very similar results. Annual O&M costs are estimated at €7.2 – 7.6 million. Annual maintenance costs for vehicles and infrastructure are 41 – 49% of this (€3.1 – 3.5 million) and operating costs, predominantly power and staffing, are 51 – 59% (€3.7 - 4.5 million). These headline operating costs are a little more than those assessed through the more detailed operational analysis in the previous chapter, but would be more precisely defined in the more detailed costing exercise as part of a fuller preliminary design study.

7 Patronage Assessment

7.1.1 It is clear from the discussion of the role of LRT in Section 1 that it performs an intermediate role between that of regular bus services and a mass transit system. Its flexibility allows it to be adapted to lower density traffic flows akin to high density bus routes and to high density flows along major corridors. An important criterion therefore in determining the feasibility of a proposed tram route or network is an assessment of its overall patronage.

7.1.2 The introduction of a tramway in itself generates some additional patronage over and above that carried by regular bus services. This relates to the defined nature of the route with a (usually) higher level of service frequency. Modern trams are often perceived as a superior mode of travel and can attract people away from cars who would not otherwise use buses and will enhance the attractiveness of using public transport as compared with the private car. This will be important for the proposed Park & Ride site at the National Stadium. The "base" level of patronage, however, will still relate to local population density and the degree of socio-economic interaction which requires people to travel.

7.1.3 It was not possible as part of this initial review of the feasibility of introducing trams to Malta to undertake a detailed demand assessment. That would be undertaken at the next stage of scheme development. As a proxy however, it was possible to review the bus patronage data collated in June 2008 during the course of the studies Halcrow is currently undertaking for the MITC. Patronage on the bus routes along the two corridors was identified and summarised in Table 7.1 below. Hourly patronage along both routes was estimated.

Table 7.1: Average Bus Patronage along Tram Corridors

Proposed Tram Routes	Existing Bus Route Nos.	Weekly Patronage	Hourly Patronage*
Valletta – Sliema	60,61,62,63,64,66,662,667,67,671,68	113,452	1,013
Valletta – National Stadium	71,74,80,84,141,142,40,42,43,44	60,088	536

- Based on average 16 hour day, 7 days per week

7.1.4 Table 4.1 shows that there is significant patronage along both corridors and that there are a large number of bus routes which service them. The patronage on the route to Sliema is approximately double that of the route to the National Stadium. The hourly patronage, however, does not show either route to be highly trafficked, although this average does not reveal the "peak hour" passenger loads or the impact on demand of the extensive residential and commercial developments taking place, particularly on the Sliema route. Future patronage may be significantly higher on both routes and needs to be assessed in more detail.

7.1.5 One of the aspects behind the patronage data is the level of "terminating" traffic at the end destinations against "through" patronage. From the bus numbers it is know that a significant level of patronage on the Sliema route is "through" traffic to destinations immediately north of Sliema centre. Whilst the tram route will improve public transport along each corridor, and allow bus services to be reorganised to "feed" them, this will not be perceived as an improvement if a significant number of "through" passengers are forced to interchange at each terminus. Reorganising the bus services to feed the tram routes should lead to significant cost savings for the MITC but it will also have important implications in developing appropriate tram/bus interchanges along the routes.

8 Models for Procurement & Funding

8.1 Introduction

8.1.1 Halcrow have been asked to consider the issues surrounding the development and implementation of a Light Rapid Transit System (LRT) for Malta. This section of the report focuses on the issues surrounding funding of such a project. In doing so this chapter concentrates on the following issues:

- Potential funding options available for the system infrastructure;
- Associated operating regimes;
- The history behind the UK LRT systems over the last 15 years.

8.1.2 This section provides an overview of potential funding options for large infrastructure projects, considers how the funding route can be aligned with the operating system through examples of the development of the UK LRT market in the last 15 years and summarises the issues raised.

8.2 Funding Options

8.2.1 This section provides an overview of the potential funding options for large scale infrastructure projects such as LRT. How to fund a project such as LRT is not necessarily straight forward. The likelihood is that a combination of funding sources would be required in putting together a funding package. This could be made up from:

- The Government of Malta – which in itself raises issues about where the funds come from (general taxation, specific taxation, government borrowing – commercial or aid banks);
- The EU through the various infrastructure funds;
- The private sector – as operators of the network or beneficiaries of the scheme, and possibly involving a third party such as an investment bank or banking consortium;
- Farebox income and associated income such as advertising or retail concession charges;
- Planning gain charges.

8.2.2 Central government is likely to be constrained by the general taxation system and the need for sound economic principles across a wide range of sectors. The ability to raise general taxation to fund a project is clearly a judgement for the Government of Malta.

8.2.3 Alternative taxation sources such as windfall taxation on businesses affected by the LRT, or on developers along the route are alternative routes to make the tax more specific to those who benefit from the investment but this approach may require primary legislation in Malta.

8.2.4 A third way is to consider funding the investment through government borrowing from commercial or international aid banks. The latter would typically provide finance at favourable rates, but would need a rationale to invest – such as identified regeneration potential of the scheme.

8.3 *Beneficiaries of a Scheme*

8.3.1 This section focuses on the scheme beneficiaries and uses and discusses moving away from central government financing towards working with the private sector in developing LRT systems. At the highest level the ultimate sources of funding for major projects should come from whoever the main beneficiaries of a scheme will be. For LRT these would be:

- LRT users – through better journey times, reliability and comfort of operation;
- Residents on the route – through improved air quality and enhanced property values;
- Operators of the system through fare revenue;
- Businesses on the route through increased passing trade and the benefits that flow from being on or close to the alignment;
- Businesses at the main destinations – Valletta, Birkirkara, Sliema, the National Stadium and so forth – through increased productivity, improved accessibility for staff and customers; and
- National Government through increased tax revenue from the above, plus an element of enhanced external perception of the modernity of Malta given the image of modern tramways as environmentally beneficial and efficient means of public transport.

8.3.2 The key issue in all this is how to capture the benefits gained from LRT and what value to put on such benefits. The impact on passengers is straightforward and paid through the farebox. The impact on the system operators is also straightforward and received from the farebox or through a financial arrangement such as availability payments, or a combination of these. However, if promoters and funders just concentrated on these effects LRT schemes would not be built. Farebox revenue at best covers the operating costs, and rarely contributes to scheme capital costs. Whereas most UK schemes approach covering their operating costs many mainland European schemes routinely receive operating support of up to 50% of operating costs.

8.4 Where Does this Leave us?

8.4.1 This general inability of the market on its own to supply and operate systems has lead the public sector to intervene and provide the upfront funds to develop LRT schemes. How this is then structured in terms of the operator can be complex and many forms of joint agreements between public and private operation have been entered into. Equally the public sector is not typically best placed to finance and operate LRT systems. There are significant upfront capital outlays, and they are often not the best in terms of introducing innovative construction, design and system operating techniques.

8.4.2 The private sector is clearly driven by the profit motive. Yet LRT schemes do not provide a strong enough revenue stream to cover capital expenditure even if they can cover operating costs. As noted above there are other potential sources of additional funds to supplement any central government monies:

- **Development Gain** – this is a common instrument throughout Europe. In this context the provision of LRT near of development site would raise the attractiveness of the site and hence its value. Extracting developer contributions to the scheme in respect of planning permission can raise significant funds – as infrastructure contributions or revenue support or some combination of each. Obviously the amount of funding available would need to reflect the gain to the developer and still respect the risks they take in the development itself. Contributions are more easily secured where the principle of funding in this way is embedded in wider development and transportation policies.

- **General Business Gain** - a key example of where this has been employed would be the funding for a new cross London underground line. The business groups in the City of London have agreed to support the government funding in recognition of the increased productivity the scheme would bring to them.

- **Existing Householder Gains** - a more difficult area. Throughout the world the development of LRT systems typically increases the value of properties along the route. However, unlike with new development sites, extracting income from such gain is difficult as authorities would have no obvious financial leverage on residents (in contrast to planning permissions for developers). Windfall taxation is clearly an option but is likely to prove unpopular and unworkable as people would not be able to extract any gains until they sold the properties, whilst the imposition of the windfall tax itself may force the sale. Whilst recovery through property rates or taxes is an option, where the system serves an area of social deprivation or lower income there may be no direct taxation route where properties are rented and possibly multi-occupied and imposition of some sort of charge may be against general policies.

8.5 *UK LRT Development*

8.5.1 In the modern era the UK has embarked on the development of a number of LRT projects. Perhaps starting with Manchester Metrolink opened in 1992 and running though to the Edinburgh LRT system currently under construction. In that period new schemes have been opened in Sheffield, Birmingham, Nottingham and London. Additionally there have been extensions to existing schemes in Manchester and the Docklands Light Railway (DLR) in London and upgrades to the systems in Newcastle and Blackpool.

8.5.2 This list may seem impressive, but there is a much longer list of failed new schemes or scheme extensions – Manchester, Birmingham, Leeds, Liverpool, Southampton and so forth. What has driven the market in LRT development, and what has changed between the ways scheme funding is structured now in comparison with the ways they were funded in the 1990s?

8.6 *UK LRT Case Studies*

8.6.1 The original forms of funding arrangements for the UK revolved around a Public/Private Partnership (PPP) structure in which consortia of designers, contractors and operators joined together to bid for the rights to design, build, finance and operate (DBFO) the systems. The public sector oversaw the competitions, and within it stipulated minimum operating conditions for the services – in effect acting as scheme sponsors.

8.6.2 The schemes themselves were not without inherent risk. Construction cost and design risk, demand forecasting and revenue risk, operating cost risks and external influence risk. The latter includes the influence of the general state of the economy and, in the UK outside London, competition from deregulated bus operators.

8.6.3 The original scheme structures arguably lead to an unsatisfactory situation for all parties. Scope creep beyond the control of the designers lead to increased costs which could not be passed on: Bus service competition and general uncertainty in demand forecasting lead to variable success in revenue terms, whilst external factors (electricity prices for example) lead to increasing operating costs. From the public sector's perspective the potential to influence the future service structures and regimes have proven to be limited and sanctions against operators ineffective.

8.6.4 This catalogue of issues lead to the next phase of tram schemes falling away due to significant increases in cost estimates. On examination it is fair to suggest that one of the key factors in risk escalation has been the increased requirement to focus on scheme risks and thus the pricing of risks, and in effect, the unwillingness of the private sector to undertake such risks at a reasonable cost.

8.6.5 The Edinburgh LRT scheme – currently under construction – is of relevance to the Maltese context. The main bus operator in the city is owned by the City Council, that in itself is important – it allows assurances on system integration to be managed in a less competitive environment, although it does not preclude other operators introducing competing services.

8.6.6 The new PPP models have structured the arrangements in a different way. They have sought to split the infrastructure development from that of the operation, and have taken a different attitude to issues such as revenue risk, especially when faced with a competitive market for public transport.

8.6.7 The PPP deal has two main contracts - an infrastructure company (InfraCo) and an operating company (OpCo). The InfraCo is responsible for system design, maintenance and vehicle provision. The OpCo contracts to the InfraCo for the operation of the services on the system. Revenue and operating cost risk lies with the public sector, but there are incentives within the contracts to direct any cost savings and revenue maximisation back to the operating companies, whilst the responsibilities of the InfraCo to maintain the system ensure long term maintenance decisions are made.

8.6.8 Central to this model is the ability of the public sector to take on the revenue risk, and thus remove such risk costs from the PPP deal. This is only really possible given the position of the council as operator of the main bus services in the area. The model is equally feasible where the bus operations are under the network control of a public body but are in fact in some way contracted out to a private operator. Some public regulation of the bus network is seen as a pre-requisite for implementation of an LRT system in Malta, both to obviate the risk of on the road competition and to positively direct the bus network where necessary to complement the LRT..

8.7 Summary and Lessons for the Maltese Context.

8.7.1 What are the implications for funding LRT in Malta? Is LRT really the way forward or are the issues too complex in the current context? The following key questions must be addressed before embarking on the funding of LRT.

- LRT is expensive to build and operate - can the country afford it?
- Is there a sufficient revenue stream to cover operating costs - if not is the Government prepared to support the service over the longer term?
- PPP can provide an opportunity to pay for major infrastructure over a number of years. This does not mean it is the cheap option. Appropriate structuring of the PPP arrangements is essential to ensure good value to all parties concerned. The key to this is testing the market's desire for investment in Malta.
- Supporting funding for a scheme can be obtained from developers with land alongside the route. What will be the political reaction to the imposition of developer gains? What proportion of total scheme costs could be levered? Is there the strategy and legislation to support this?
- Residents along the route would similarly gain from house price increases. What would be the reaction to windfall taxation on incumbents? What proportion of scheme costs could be extracted?
- Businesses in Valletta and other locations would be particular beneficiaries of the scheme. What is known of their reaction to the project? What potential is there to gain business financial support in a similar vein to the experiences in London?

9 Conclusions and Recommendations

9.1 General Conclusions

9.1.1 Under the remit from the MITC Halcrow has been able to verify the proposed tram network for Malta. It has been possible to identify and define two separate routes from Valletta to Sliema and from Valletta to National Stadium (via Birkirkara), integrating them into a distinct network. The ADT proposals for the route to Sliema have been reviewed, and the routing to Birkirkara using the old tram route preferred to the original proposal of using the former railway route. It is not envisaged that there will be technical hurdles which will preclude the development of either route.

9.1.2 The patronage and frequency of the existing bus services to the two destinations indicate there is a significant level of demand but additional analysis is necessary to confirm whether the demand and revenue is sufficient. Future demand should be higher than existing bus patronage due to the extensive commercial developments which are planned, particularly on the route to Sliema. In addition, patronage from the proposed Park & Ride site at the National Stadium could be significant, especially if combined with traffic constraint measures to reduce car access along the route to Valletta.

9.1.3 Capital funding to cover their construction and implementation costs, estimated at approximately €221 - €325 million. Annual fare revenue, conservatively estimated at €4.3 million, would only part cover the annual operating and maintenance costs, estimated at approximately €7.2 – €7.6 million. The balance would therefore require an ongoing Government subsidy.

9.2 Specific Conclusions

9.2.1 We consider that the Valletta-Sliema route as developed by ADT is sufficiently robust, subject to incorporation of our proposed amendments, to warrant its further technical development to full engineering feasibility stage. This would involve confirming the vertical and horizontal track alignment, confirmation of tramstop locations, the development of associated traffic management measures and development of bus interchange facilities.

9.2.2 We consider that the Valletta-Birkirkara-Ta'Qali National Stadium route as identified by Halcrow with the assistance of our MITC colleagues is in principle, viable. It will require a full topographic survey of the route and further on-site technical examination provide a practical solution to any potential alignment constraints and so "prove" the route to our collective satisfaction; but we have no doubt that any such constraints can be overcome.

9.2.3 We consider that the concept of developing an interchange between the two routes, whether at Sa Maison or Porte des Bombes, will provide worthwhile flexibility in operation and improved passenger/route choice.

9.2.4 We consider that there can be no better and appropriate location for the tramway Depot and Operations Control Centre than at the out-of-town Ta'Qali terminus.

9.3 Recommendations

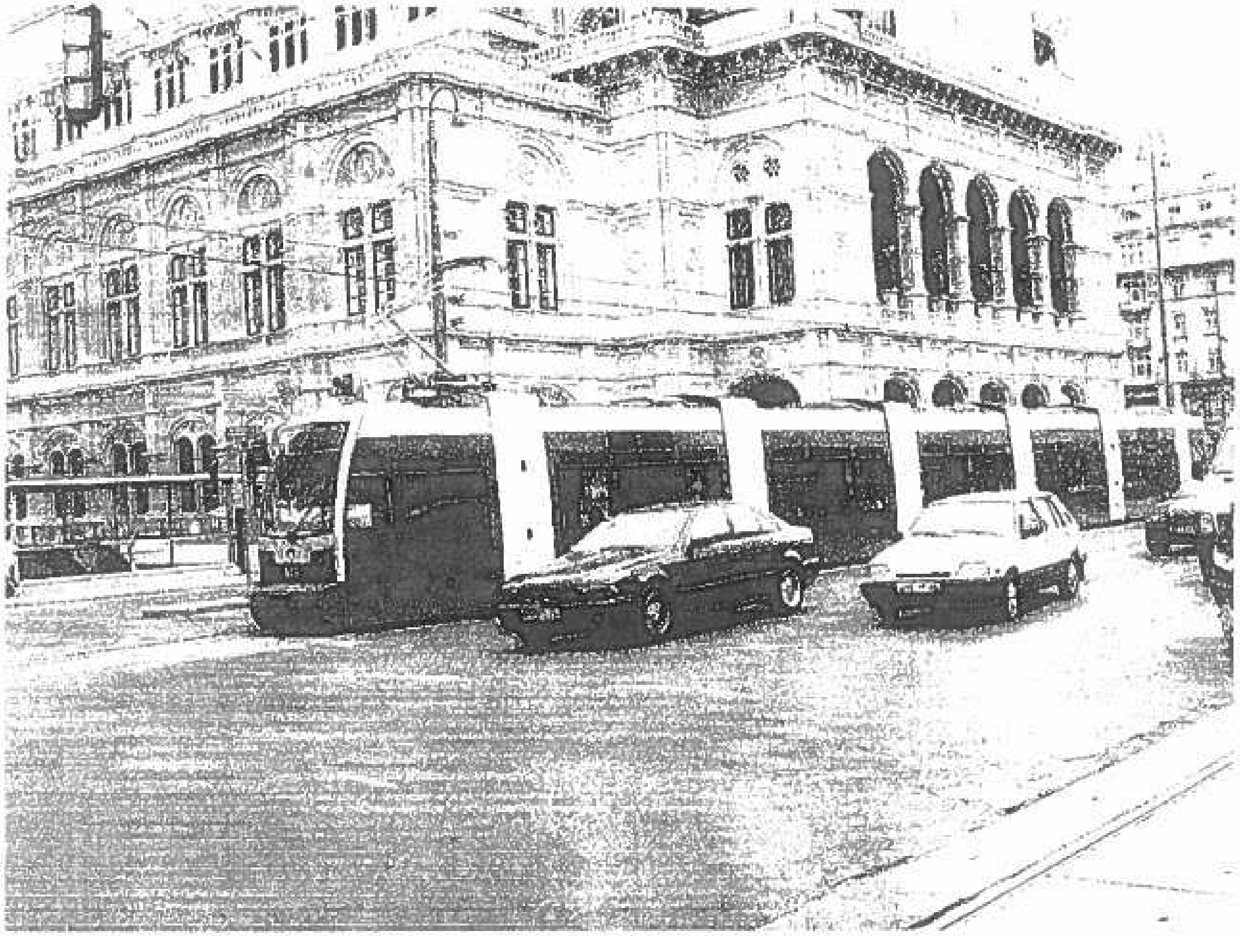
9.3.1 There is clearly a desire on the part of MITC to introduce such as service which needs to be proven technically and economically. We recommend that on consideration of this report, the MITC develop the proposed tram system in more detail by commissioning a series of staged feasibility studies; staged in order to avoid MITC incurring potentially abortive expenditure in system development should the proposals fail to obtain ongoing support politically or with the communities concerned.

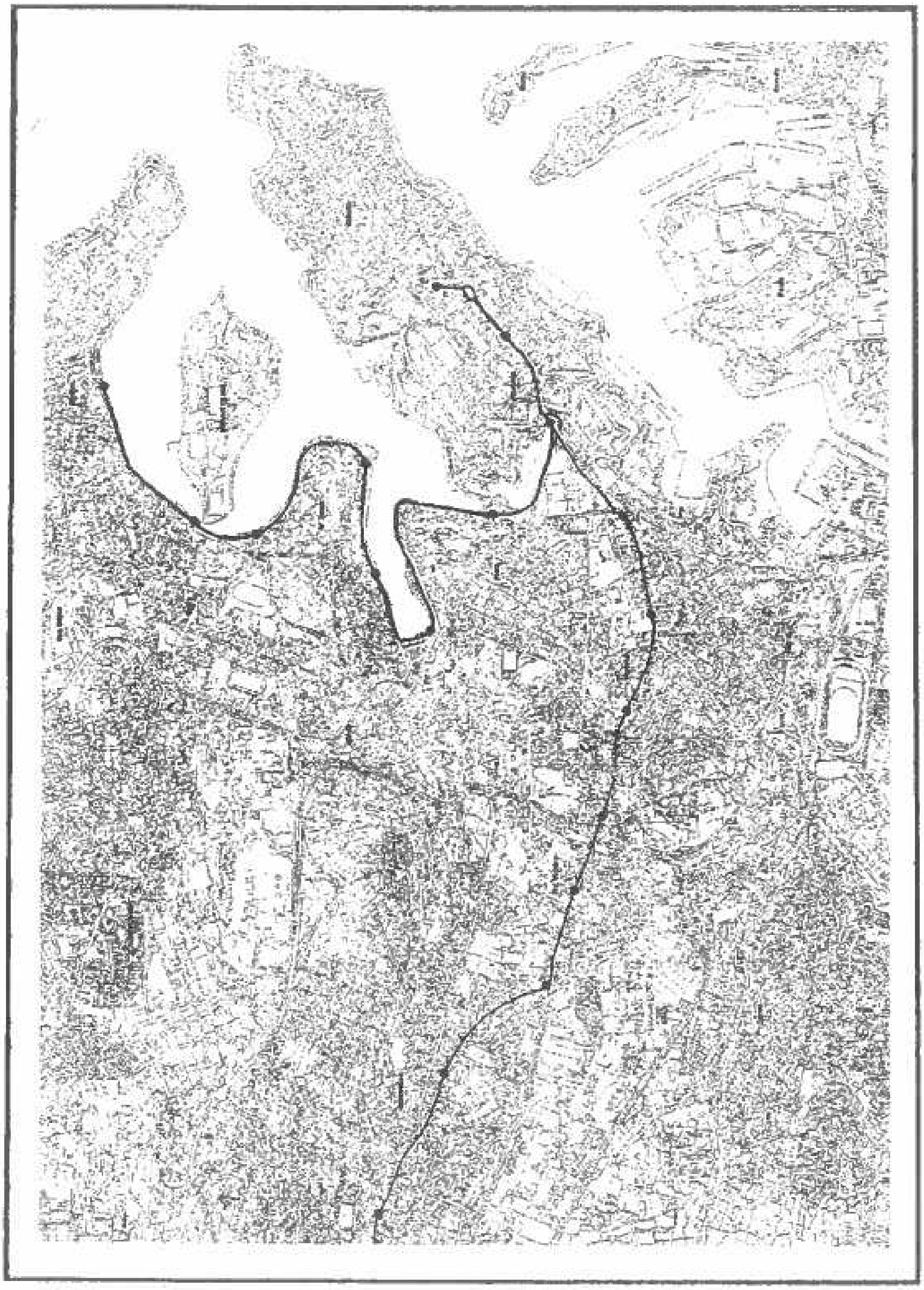
9.3.2 These studies would consider in detail:-

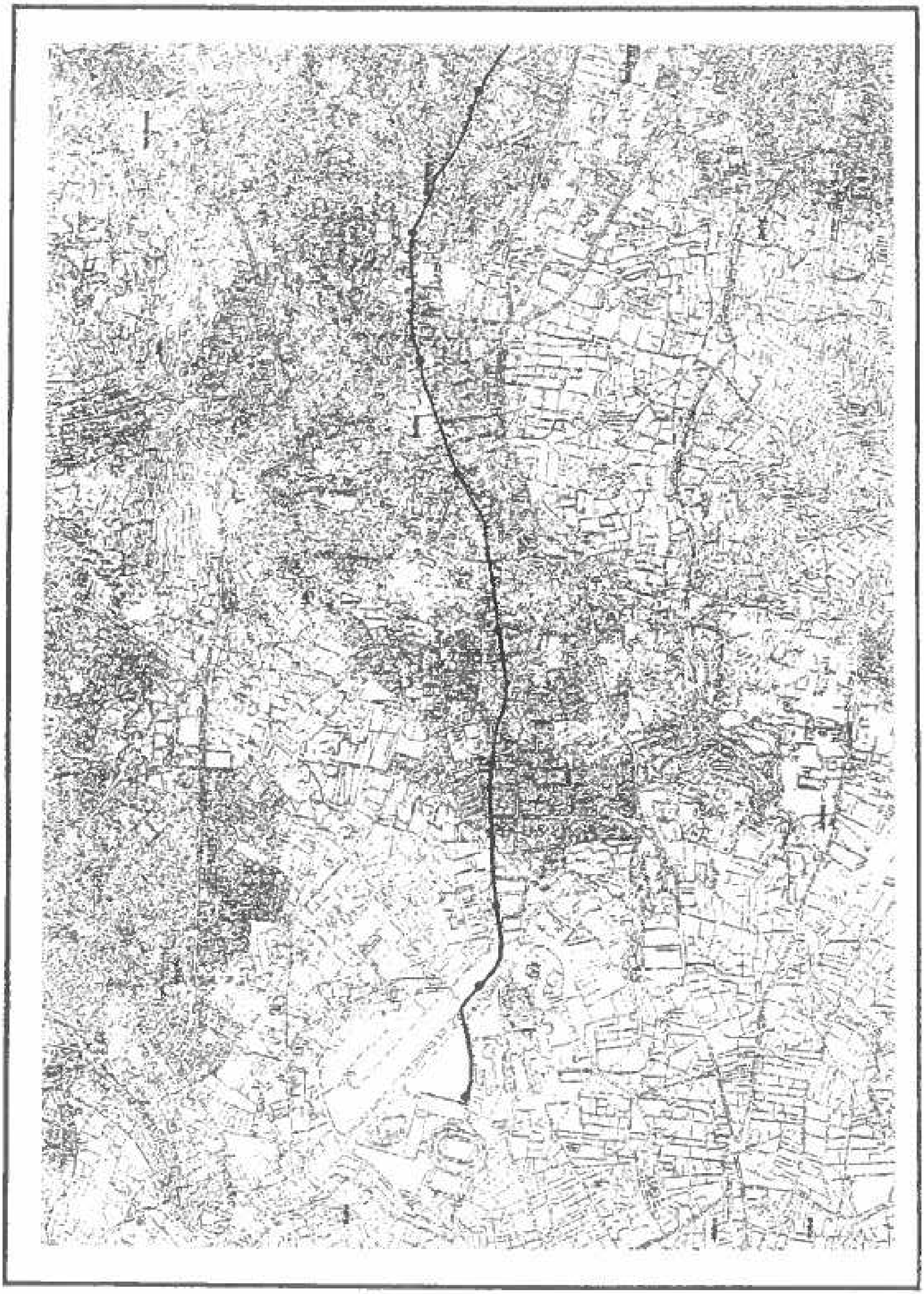
- Patronage on existing bus services and surveys of bus users
- Analysis of passenger car data
- Surveys of car users and the likelihood to transfer to an tram service
- Assessment of existing and future traffic congestion
- Assessment of impact of socio-economic land use changes
- Revenue analysis, financial & economic analyses
- Technical analysis of preferred route and engineering solutions
- Detailed route assessment and description of preferred alignment
- Civil engineering assessment of structures
- Electrical assessment of power supply
- Rolling stock assessment of tram solutions
- Traffic management assessment of tram/vehicle interface
- Institutional and contractual assessment
- Environmental assessment

9.3.3 The aim of this feasibility study would be to develop the proposed tram network technically and economically to a "bankable" level. This can then be used to seek funding from international funding organisations and will guide contracting organisations who wish to design, construct and/or operate the proposed network.

Vienna Tram in-street situation





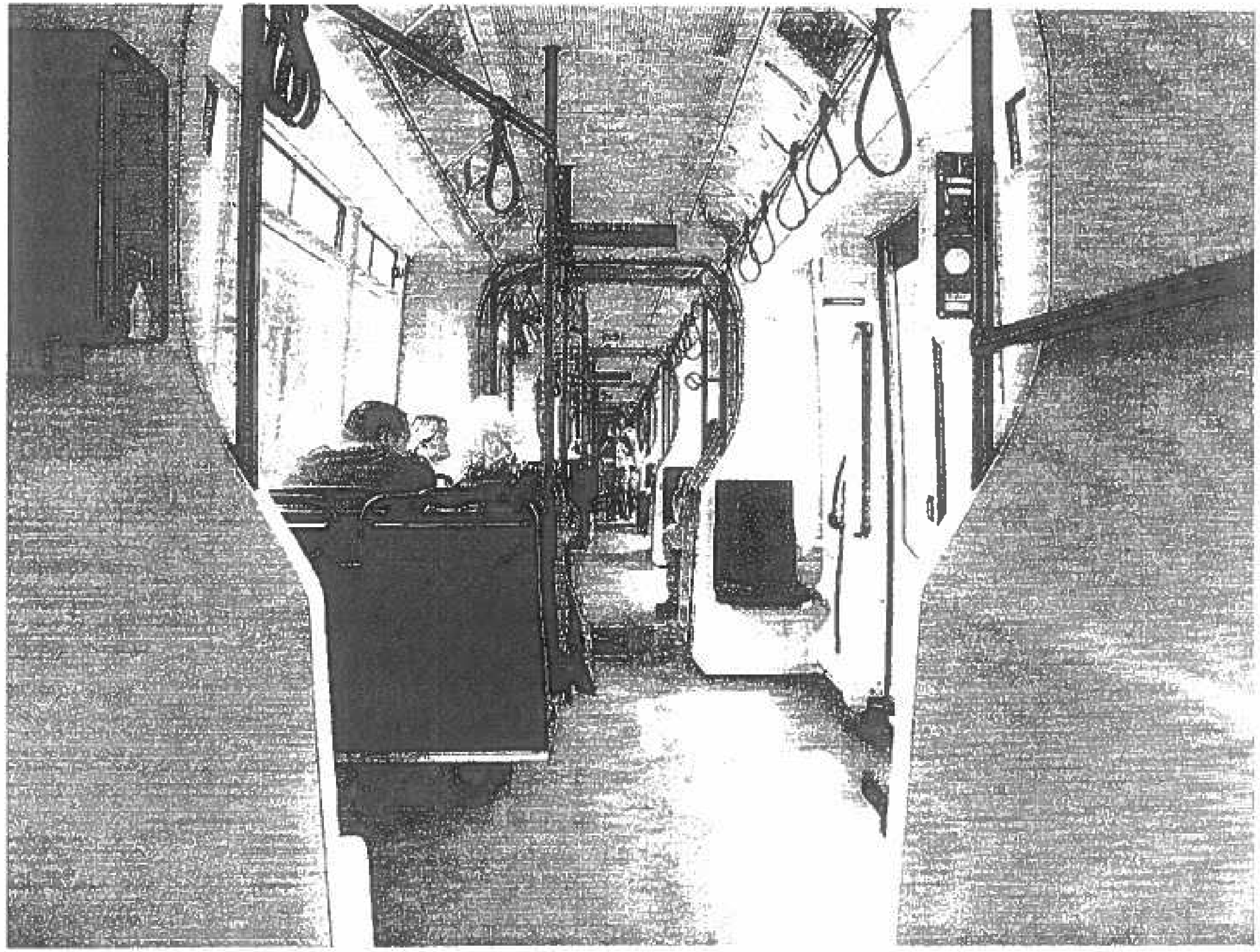


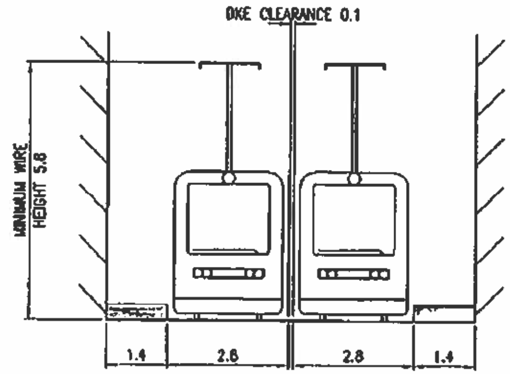
Appendix - Vehicle Specifications

Make	Model	Max Speed (km/h)	Length (m)	Width (m)	Height (m)	Max Gradient (%)	Max. Horiz. Curve (m)	Max. Vertical Curve (m)	Seats + Standing at 4/sq.m	Cost per vehicle (€)m	Comments
Alstom	Citadis	not known	not known	not known	not known	not known	not known	not known	not known	2.84	Trams for Dublin (IE) from 2008
Alstom	Citadis	not known	not known	not known	not known	not known	not known	not known	not known	2.85	Trams for Nice (FR) from 2008
Alstom	Coradia	not known	not known	not known	not known	not known	not known	not known	not known	2.14	Lightweight DMU ordered for Germany in 2004
Alstom	Dualis	100	32m 52m	2.4m 2.65m	3.37m	not known	not known	not known	251+? 292+?	not known	10-12 section tram-train marketed as part of Citadis range.
Ansaldo Breda	Sirio	not known	20.2m	2.3m	3.41m	not known	not known	not known	31+124	not known	Three section tram used in Napoli (IT)
Ansaldo Breda	Sirio	not known	25m 35m	2.4m	not known	not known	not known	not known	50+191 71+285	not known	Five or seven section tram used in Milano (IT)
Ansaldo Breda	Sirio	70	31.9m	2.4m	3.3m	not known	not known	not known	42+160	not known	Five section tram used in Firenze (IT)
Ansaldo Breda	Sirio	80	29.35m	2.65m	3.332m	not known	not known	not known	83+96	not known	As used in Goteborg (SE)
Bombardier	Flexity	80	35m	2.65m	not known	6.8%	18m	not known	80+215	not known	7 section tram, used in Porto (PT). Based on Strasbourg "Eurotram" design
Bombardier	Flexity	not known	32.37m	2.4m	not known	6%	20m 25m	not known	56+132 50+150	not known	As used in Palermo (IT) and Valencia (ES)
Bombardier	Flexity	not known	not known	not known	not known	not known	not known	not known	not known	3.25	Used in Rotterdam (NL) from 2007
Bombardier	Flexity	not known	not known	not known	not known	not known	not known	not known	not known	2.125	Ordered by Manchester Metrolink (UK) for 2009

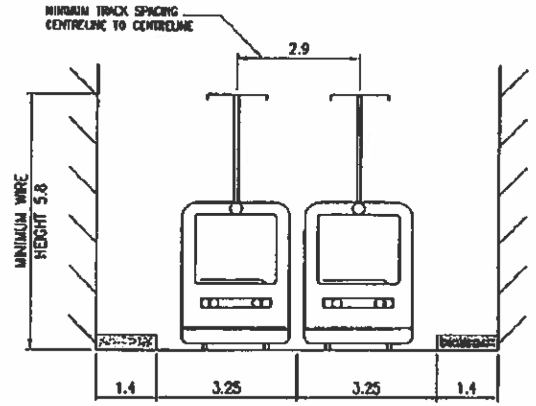
Make	Model	Max Speed (km/h)	Length (m)	Width (m)	Height (m)	Max Gradient (%)	Max. Horiz. Curve (m)	Max. Vertical Curve (m)	Seats + Standing at 4/sq.m	Cost per vehicle (€)m	Comments
Bombardier	Flexity	not known	not known	not known	not known	not known	not known	not known	not known	2.88	Used in Stockholm (SE) from 2006
Bombardier	Flexity	not known	not known	not known	not known	not known	not known	not known	not known	2.05	Used in Frankfurt (DE) from 2006
Bombardier	Flexity Outlook	not known	not known	not known	not known	not known	not known	not known	not known	4.72	As used in Geneve (CH)
Crotram	TMK2200	not known	not known	not known	not known	not known	not known	not known	not known	7.85	Used in Zagreb (HR) and ran on trials (not successfully) in Helsinki (FI).
Siemens	Avanto	100	36.97m	2.65m	3.52m	not known	20m	not known	80+162	not known	Tram-train used in Paris (FR)
Siemens	Avanto	88.5	27.7m	not known	not known	not known	25m	not known	80+162	not known	Tram-train used in San Diego (US)
Siemens	Combino Plus	not known	36.4m	2.65m	not known	not known	not known	not known	232 tot	not known	Tram used by MST Sul do Tejo (PT)
Siemens	ULF	70	24.21m 35.47m	not known	not known	not known	not known	not known	not known	2.38	Used in Vienna from 2008
Siemens	Combino	70	20m 31.5m	2.3m	3.5m	not known	15m	not known	37+68 60+120	not known	Used in Erfurt (DE)
Siemens	Combino Plus	70	54m	2.4m	not known	not known	not known	not known	325 tot	3.725	Tram used in Budapest from 2004(HU)
Siemens Duewag	not known	80	34.75m	2.65m	not known	10%	not known	not known	88+152	not known	Sheffield since 1992. 10% achieved by all 8 axles being powered.
Stadler	Be4/6 & 4/8	not known	not known	2.4m	3.65m	not known	not known	not known	not known	not known	Used in lightweight rail applications on Forchbahn and Trognerbahn (CH)
Stadler	Tango	80	45m	2.3m	3.5m	not known	12m	not known	94+182	not known	Ordered by BLT and BVB systems in Basel (CH)

Vienna Tram interior

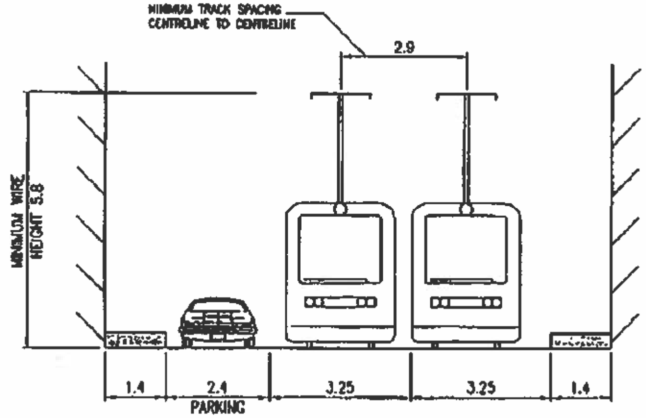




ABSOLUTE MINIMUM CROSS SECTION
TRAM EXCLUSIVE ON-STREET



MINIMUM CROSS SECTION
SHARED TRAM/TRAFFIC LANES
NO PARKING ON-STREET



MINIMUM CROSS SECTION
ON-STREET PARKING PLUS SHARED TRAM/TRAFFIC LANES

Notes:

1. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE SHOWN.
2. ASSUMED TRAM DIMENSIONS: (BOMBARDIER FLEXITY TYPE) BODY WIDTH 2.5m (narrow) BODY HEIGHT 3.2m BODY LENGTH 34.0m TRACK GAUGE 1.435m (standard) ASSUMED
3. IN AN OFF STREET SITUATION WITH TRACTION POLES BETWEEN THE TRACKS, THE MINIMUM OKE CLEARANCE IS 0.6m
4. ALLOW ADDITIONAL WIDTH FOR OKE WIDENING ON CURVES

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Halcrow

Project: MALTA TRAM PROJECT

Drawing: TRAM CROSS SECTIONS

Drawn by	GC	Date: 07/10/09
Checked by		Date: 07/10/09
Authorised by		Date: 07/10/09
Drawing No.	CTBALI/0000/001	Revision 0
Drawing Scale: 1:100		
CAD Filename:		Plot Scale: